# Optimal Site Selection of Electric Vehicle Charging Station Based on the AHP-VIKOR method

**Abstract.** Site selection of Electric Vehicle Charging Stations (EVCSs) contributes a significant role in the development of sustainable and green transportation systems. On the basis of a literature review and a sustainable point of view, the ranking of EVCS site selection contains some essential criteria like population, air quality, cost, number of EVs served, and distance to the main city, etc. In this paper, a new hybrid model of EVCS site selection based on MCDM (multi-criteria decision making) VIKOR (VIekriterijumsko KOmpromisno Rangiranje) ranking method is proposed. At first, the evaluation criteria are selected and then Analytical Hierarchy Process (AHP) method is adopted for the computation of weights of EVCS criteria. Ultimately, the VIKOR method is used to get the rank of alternative EVCS sites. The proposed paper established an advanced research methodology by considering uncertainty, qualitative and quantitative aspects in the evaluation of optimal site selection, and a preference ranking organization MCDM technique i.e., VIKOR is used for the advancement of selection of EVCS sites.

## 1. Proposed Hybrid Model

This section explains, a hierarchy model for the selection of EVCS sites that is designed based on the AHP approach. There are three levels of the hierarchy decision process adopted for the selected optimal site of EVCS as depicted in Figure 5.1. At the topmost level of the hierarchy i.e., Level I, the objective or the goal of the decision was announced. In specific, the objective goal of the present application was to find out the optimal site for EVCS. In Level II, the main attributes that impact the choice of the optimal site are presented. In this research work, the main attributes which are considered: are population, air quality, cost, distance to the main city, and number of EVs served per day. Finally, in level III, the four alternative solutions that potentially met the objective of the proposed work were listed and shown in Figure 5.1. The proposed hybrid model is an efficacious MCDM technique that is a combination of AHP and VIKOR-MCDM techniques. Every MCDM methods have the competence of problem-solving proficiencies [25]. However, AHP prompts very well from the beginning, and with the help of a comparison matrix, it raises the adaptability and accuracy of decision-making. The AHP model is used to evaluate the weights of each criterion. On the other hand, VIKOR is a significant ranking method that is very much useful for the selection of optimal alternatives. Moreover, the hybrid MCDM model in a combination of AHP and VIKOR shows an effective MCDM technique for the selection of the optimal site of EVCS among the alternatives [12-2] [18] [29].

The steps of the proposed model are as follows:

Step-1. Recognition of the criteria for preparation of pairwise comparison matrix.

Step-2. Formulation of the weight matrix using the AHP method.

Step 3. Normalization of the weight matrix and consistency test

Step 4. Rank computation of all alternatives using the VIKOR method.

The details of the above steps for the proposed hybrid model are explained in section 6.

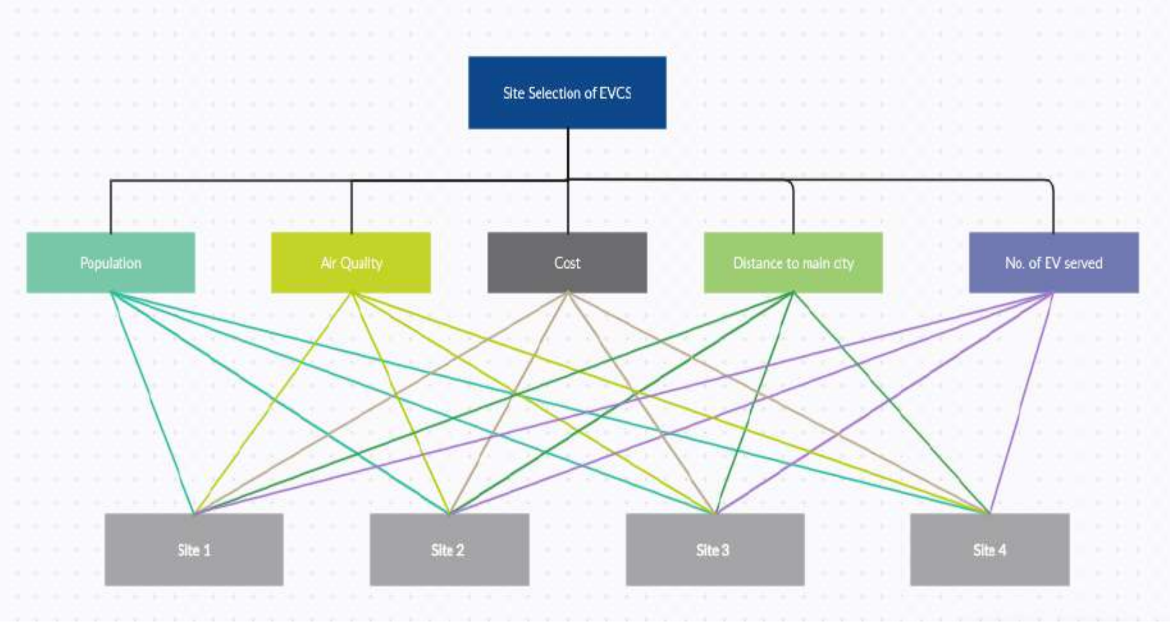

**Figure 5.1**. The hierarchy model for the selection of EVCS sites

## 2. Results & Discussion

In the proposed research work, the five different conflicting parameters such as population, air quality, total construction cost, the total number of EVs served per day, and distance of the site from the main road are identified to choose an optimal site for EVCS. Subsequently, the AHP method is applied, and the pair-wise criteria matrix was created that was presented in Table 6.1. Now criteria weights are computed by conventional AHP techniques and then the maximum Eigen value i.e., λm of the matrix is formulated. From Table 6.2, it was observed that among the five conflicting criteria, the weight of distance to the main city is the highest (0.43) and the air quality weight is the lowest (0.5). For the judgment of acceptance, the consistency index (CI) is formulated from Step Vas mentioned in Section 3 and shown in Table 6.2, and chose random index from Table 6.1. After that, the consistency ratio (CR) is calculated in Table 6.2, from Step V in Section 3. We know that the consistency ratio acceptability range is less than 0.1. Subsequently, the VIKOR technique was adopted for the final choice of the optimal EVCS site. Here we have identified four locations where we want to construct the EVCS. The locations are Kolkata, Chinsurah, Durgapur, and Bankura. The variation of different attributes values for all four locations are plotted in Figure 6.1 where the unit of population is measured in terms of thousand, air quality (PM2.5) unit is µg/m$^2$, cost in terms of lakhs, and distance to the main city is measured in meters.

**Table 6.1**. The matrix of pairwise comparisons of the criteria

| | **Population** | **Air Quality** | **Cost** | **Distance to main city** | **No. of EV served** |
|---|---|---|---|---|---|
| **Population** | 1 | 3 | 0.5 | 0.25 | 0.33 |
| **Air Quality** | 0.33 | 1 | 0.25 | 0.14 | 0.2 |
| **Cost** | 2 | 4 | 1 | 0.33 | 0.5 |
| **Distance to the main city** | 4 | 7 | 3 | 1 | 2 |
| **No. of EV served/day** | 3 | 5 | 2 | 0.5 | 1 |

**Table 6.2.** The weights of individual criteria and consistency test

| | **Criteria Weights** | **Consistency Test** |
|---|---|---|
| **Population** | 0.10 | Consistency index (CI) = ($\lambda_m$-n) / (n -1) = 0.019 |
| **Air Quality** | 0.05 | Random Index (RI) = 1.12 |
| **Cost** | 0.16 | Consistency Ratio (CR) = CI/RI =0.017 |
| **Distance to main city** | 0.43 | |

| | |
|---|---|
| **No. of EV served/day** | 0.26 |

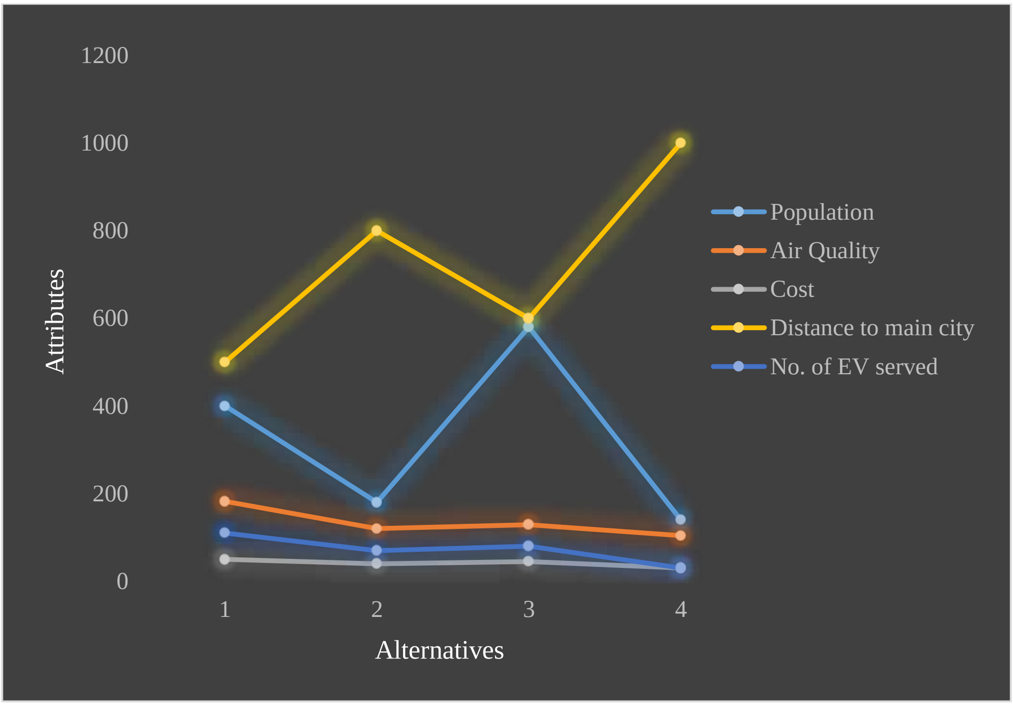

**Figure 6.1.** Values of different attributes for all four alternatives

The VIKOR steps are followed as explained in Section 4 and calculate the rank evaluation matrix, as illustrated in Table 6.3. The overall rank calculation was done by considering all the attributes for each alternative and Table 6.3 shows that the VIKOR method evaluated the lowest rank for location Kolkata i.e., rank 1, and then Durgapur, Chinsurah, and Bankura respectively in increasing order. Hence, the EVCS site option Kolkata is selected as the best site among all other alternatives.

Table 6.3. The rank evaluation of all alternatives

| Attribute/ Alternatives | Population | Air Quality | Cost | No. of EV Served/Day | Distance to Main Road | $S_i$ | $R_i$ | Rank |
|---|---|---|---|---|---|---|---|---|
| **Kolkata** | 0.0409 | 0.05 | 0.16 | 0 | 0 | 0.2509 | 0.16 | 1 |
| **Chinsurah** | 0.0909 | 0.010256 | 0.08 | 0.215 | 0.156 | 0.5522 | 0.215 | 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Duragpur** | 0.0000 | 0.016026 | 0.12 | 0.16125 | 0.052 | 0.3493 | 0.161 | 2 |
| **Bankura** | 0.1000 | 0 | 0 | 0.43 | 0.26 | 0.7900 | 0.43 | 4 |
| | | | | Min | $S_{i*}$,$R_{i*}$ | 0.2509 | 0.16 | |
| | | | | Max | $S_{i\#}$,$R_{i\#}$ | 0.79 | 0.43 | |